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AIR POLLUTION - A NATIONAL SAMPLE

Public Health Service
Washington, D. C.

1966

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PRINCIPAL AIR POLLUTANTS AND THEIR EFFECTS

At levels frequently found in heavy traffic, *carbon monoxide* produces headache, loss of visual acuity, and decreased muscular coordination.

Sulfur oxides, found wherever coal and oil are the common fuels, corrode metal and stone, and at concentrations frequently found in our larger cities reduce visibility, injure vegetation, and contribute to the incidence of respiratory disease and to premature death.

Beside their contribution to photochemical smog, described below, *nitrogen oxides* are responsible for the whisky brown haze that not only destroys the view in some of our cities, but endangers the takeoff and landing of planes. At concentrations higher than those usually experienced, these oxides can interfere with respiratory function and, it is suspected, contribute to respiratory disease. They are formed in the combustion of all types of fuels.

Hydrocarbons are a very large class of chemicals some of which, in particle form, have produced cancer in laboratory animals, and others of which, discharged chiefly by the automobile, play a major role in the formation of photochemical smog.

Photochemical smog is a complex mixture of gases and particles manufactured by sunlight out of the raw materials—nitrogen oxides and hydrocarbons—discharged to the atmosphere chiefly by the automobile. Smog, whose effects have been observed in every region of the United States, can severely damage crops and trees, deteriorate rubber and other materials, reduce visibility, cause the eyes to smart and the throat to sting, and, it is thought, reduce resistance to respiratory disease.

Particulate matter not only soils our clothes, shows up on our window sills, and

scatters light to blur the image of what we see, it acts as a catalyst in the formation of other pollutants, it contributes to the corrosion of metals, and in proper particle size can carry into our lungs irritant gases which might otherwise have been harmlessly dissipated in the upper respiratory tract. Some particulates contain poisons whose effects on man are gradual, often the result of the accumulation of years.

AIR POLLUTION IS A COMPLEX PROBLEM

Both the nature and the seriousness of the problem of air pollution can vary from place to place, from season to season, even from hour to hour. Photochemical smog, for example, does not occur at night. In northern parts of the country sulfurous pollution usually is more serious in the cold weather months because we burn more fuel for heating. In southern sections of the country sulfurous pollution may go up in the warm weather months because of the increased air-conditioning load on our powerplants. The damaging effects of gaseous pollutants commonly are multiplied when particulates are also present in the air. Some segments of the population are particularly vulnerable to the health effects of air pollution.

The major variables affecting the nature and seriousness of the air pollution problem at any one time and place are . . .

- Types of pollutants
- Quantity of pollutants
- Wind speed and direction
- Topography
- Sunlight
- Precipitation
- Decrease or increase in air temperature with height
- Susceptibility of the individual to particular pollutants or combinations of pollutants.

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air pollution– a national sample

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Division of Air Pollution Washington, D.C. 20201
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PREFACE

One way we can keep track of the growth of air pollution, and of our efforts to cope with it, is to go out every once in awhile and take samples of the air and measure what is in them. This is not as simple as might appear at first glance. Air pollution varies widely from place to place and from time to time. Carbon monoxide, for example, which is the reason we don't run an automobile in a closed garage, is many times more dense in tunnels and along clogged freeways than it is outside a second-story window. Oxidants, which are the principal ingredients of photochemical smog, may reach high enough levels in the afternoon to cause our eyes to water and our throats to sting, but they will virtually disappear at night. The sulfur oxides, which are found in the air wherever coal and oil are common fuels, are in most places more abundant in the winter than they are in the summer. In the center of the city, where the buildings and the traffic are pretty much the same today as they were 10 years ago, the levels of air pollution may be increasing only slightly; but in the outskirts, where our cities are growing, where what was once a farm is now a housing development, where industrial parks and beltways and high-rise apartments seem to spring up overnight, the air that used to be fresh may now be pretty foul.

The problem, then, is how to get samples of air that truly represent the atmosphere of a particular place. This book describes the attempts we have made so far to measure the quality of the air that most of us breathe.

THE AIR SAMPLING NETWORKS

In 1953, when the Public Health Service set up the National Air Sampling Network (NASN) to measure solid pollutants in the air, the problem of air pollution was regarded as just that—the nuisance of such familiar solids as smoke and fly ash. NASN started with monitoring stations in 17 of the dirtiest cities, with the Public Health Service providing equipment and State and local agencies providing manpower. As more and more communities wanted to participate in the network, NASN expanded, and by 1957 there were 66 stations in the network.

During this period we were becoming more and

more aware of the true nature of the air pollution problem. We were beginning to understand that there were a lot of things in the air, many of which we couldn't see, that threatened us in far more serious ways than the aggravation of changing shirts. We were becoming aware of the vast quantities of gaseous pollutants in the air and of the threat these gases as well as the solid pollutants posed to our health and welfare.

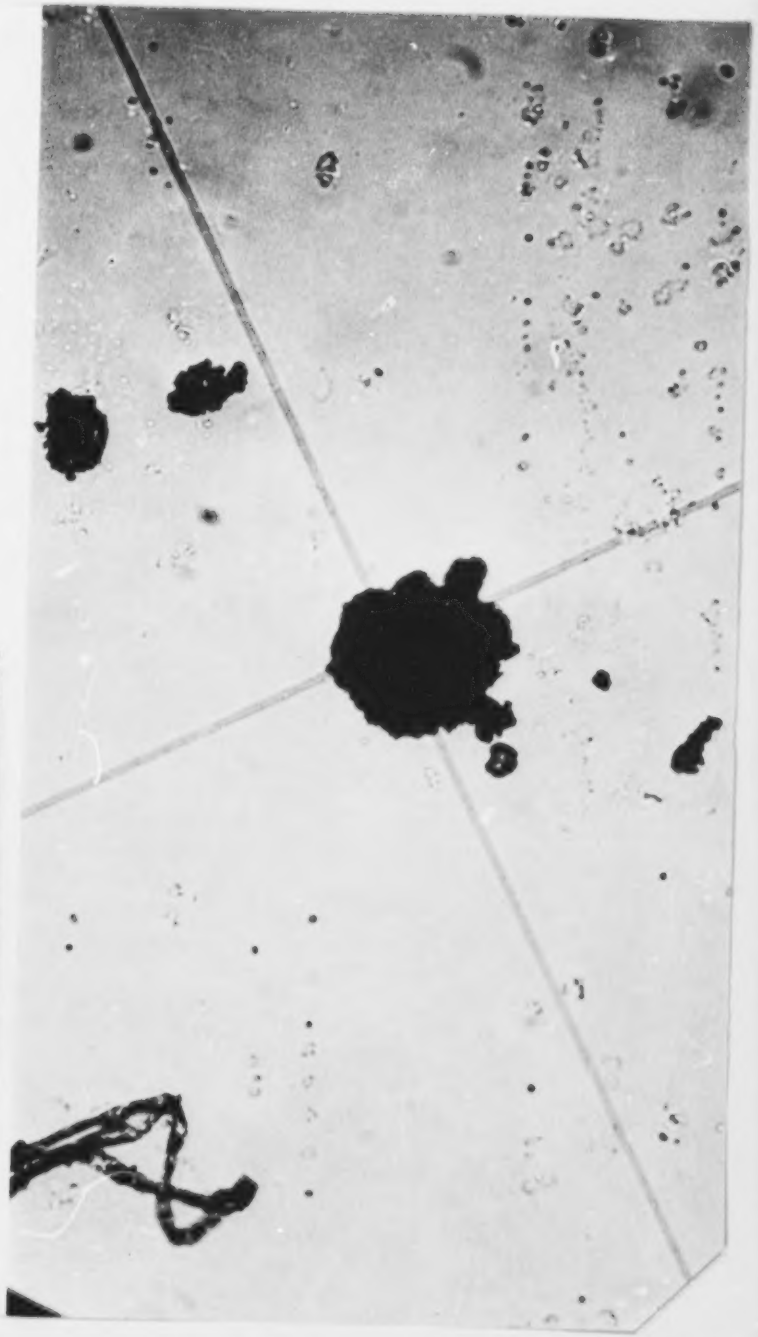
In 1960 NASN began limited sampling for gaseous pollution, and in 1962 the Public Health Service initiated the Continuous Air Monitoring Program (CAMP) to intensively measure gaseous pollution in representative urban areas. The very sophisticated CAMP equipment was set up in six cities to continuously measure concentrations of six major gaseous pollutants. The cities were selected to represent as wide a variety as possible of the factors which influence the air pollution problem—climate, topography, type of industry, principal fuel used, and so on. They thereby gave us a base of information as broadly applicable to all our urban areas as six stations could be.

The CAMP stations are supplemented to some extent by State and local sampling networks, as are the NASN stations, of which there are now about 200 urban and 30 nonurban.

THE POLLUTANTS BEING MEASURED

SOLIDS

Solid pollutants include common fly ash and dust, and a wide variety of less familiar substances that are discharged from many different sources.



Solids discharged into the air either soon settle to the ground or else remain suspended, generally until they are washed from the air by rain or snow, or until they lodge on buildings. Those that settle are called *dustfall*, and those that don't are called *suspended particulates*. After they have been collected, solid pollutants are weighed and frequently analyzed. NASN regularly analyzes samples of suspended particulates for organic matter, nitrate and sulfate compounds, and over a dozen different metals.

GASES

Several gaseous pollutants are monitored continuously at CAMP and local monitoring stations throughout the country. Some are measured periodically at a large number of NASN, State, and local stations, and further data are gathered from time to time throughout the country with portable equipment. The following gaseous pollutants are measured continuously at the CAMP stations: *carbon monoxide, nitric oxide, nitrogen dioxide, sulfur dioxide, total hydrocarbons*, and *total oxidants*. Carbon monoxide and sulfur dioxide are the pollutants most commonly measured by State and local agencies; NASN measures levels of sulfur dioxide and nitrogen dioxide.

THE TOOLS USED FOR MEASURING POLLUTANTS

SOLIDS

Dustfall is measured by weighing the contents of a bucket or jar which has been left out in a suitable spot, usually for a month. Dustfall jars are in common use by agencies at all levels of government. They are cheap, require a minimum of attention, and not much skill is needed in using them, but they provide only a crude measure of pollution.

Two tools are commonly used to measure the

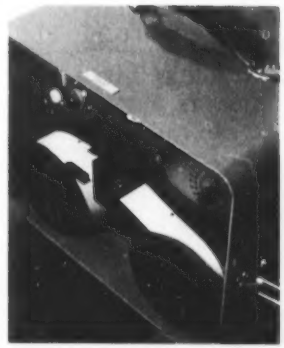
suspended particulates: the high-volume air sampler, commonly called the hi-vol, and the spot tape sampler. They require electric power, laboratory facilities, and skilled technicians.

The hi-vol is essentially an out-of-doors vacuum cleaner. To take a sample, air is drawn through the hi-vol for a fixed period of time, usually 24 hours, and particulates suspended in the air are deposited on its filter. At the end of this time the filter, which has normally changed color from snow white to black, is removed and the deposits on it are weighed and often analyzed chemically. NASN operates some 200 hi-vol stations from coast to coast, and many more are regularly operated by State and local agencies.

The spot tape particulate sampler is also a vacuum cleaner, but it is smaller than the hi-vol and portable. It is easily stationed wherever measurements of suspended particulates are desired. Air is drawn through a 1-inch-diameter hole and particulates are deposited on a filter paper tape. A sample is obtained in 1 or 2 hours, as desired, and then the tape automatically advances for the next sample.

GASES

Over nine-tenths of the air's man-made pollutants are gases. Despite this fact much less



data has been obtained on gases than on solid pollutants, and, although the greater importance of the gases has been recognized for some time, data collecting for gases is still less extensive than for solids. The data about gases that have been collected, however, are generally more intensive and more detailed than the data for solids.

The six CAMP stations in the country and several similar continuous monitoring stations operated by local agencies provide most of our data on gaseous pollutants. Sophisticated equipment analyzes the air drawn from the atmosphere and automatically records the pollutant levels in two ways: a pen leaves a trace of the concentration level of each of the gases on a moving chart and, at 5-minute intervals, the concentration is translated into a numerical value, and this value is punched on a paper tape from which tabulations are printed. CAMP stations, besides monitoring the nearby ambient air, can also be used to analyze samples of air collected in plastic bags anywhere a spot check is desired.

In addition to the CAMP stations, "bubbler" samplers are used to measure gaseous pollutants. A small fan bubbles air through test tubes of various chemical solutions, each of which reacts in a measurable way with a specific gas. Bubblers are small and can easily be moved, but they require a source of electric power and some degree of expertise in their use. NASN gathers bubbler samples of sulfur dioxide and nitrogen dioxide at 40 to 50 stations.

HOW MUCH AIR POLLUTION DO WE HAVE?

This question has no simple answer. In the first place, air pollution is a complex brew whose ingredients fluctuate, some with the hour of the day, some with the season of the year, and some with the coming of rain. In the second place, air pollution is not only different in our cities and industrial towns than it is in rural areas, it varies from city to city and from area to area within a city.

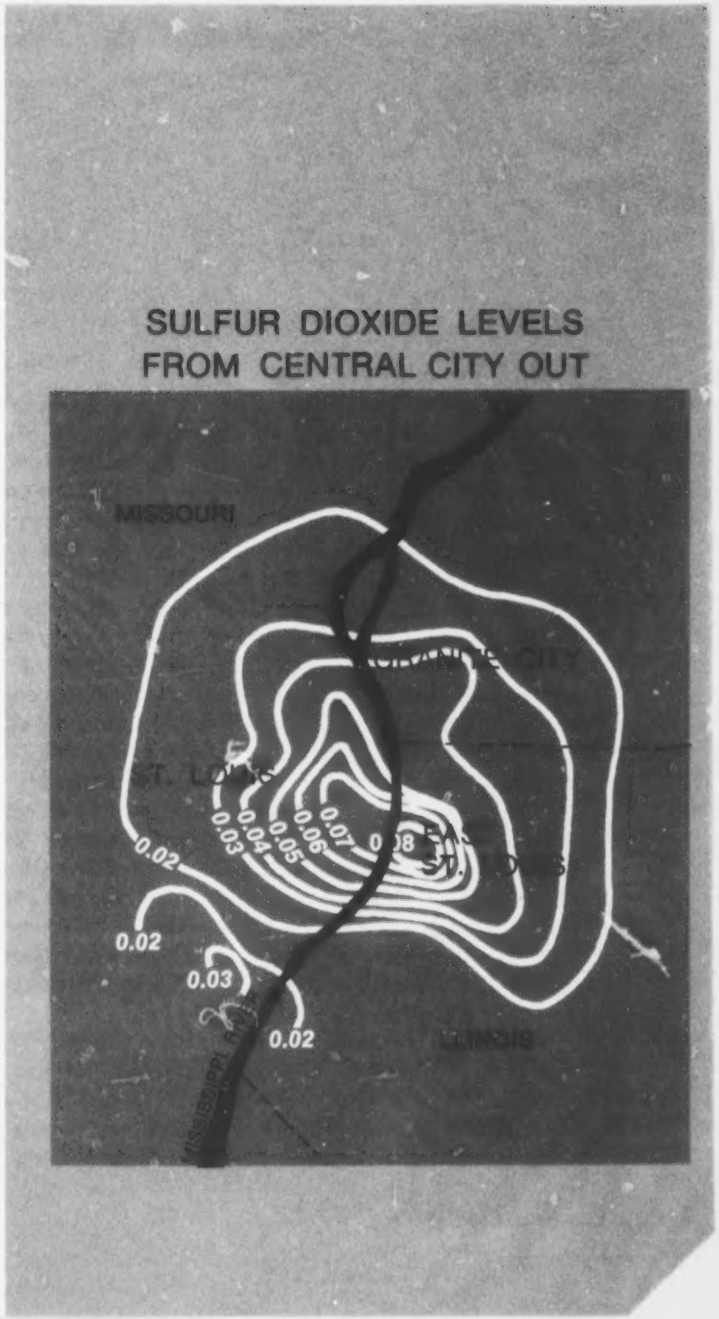
Aside from the 30 nonurban NASN stations, the NASN and CAMP instruments are generally located in the downtown area of a city, where there is rarely space for the construction of additional sources, where the operation of existing facilities is steady, and where peak traffic flow is near saturation. In other words, as far as air pollution is concerned, this location is generally the most

stable one in the city. Growth of population in the suburbs, the construction of industrial parks, the enlargement of traffic arteries, and other reflections of the major changes that are taking place in our metropolitan areas will have some effect on air pollution levels downtown; however, the levels of pollution downtown will be affected for the most part by changes in the sources of pollution downtown.

This stability of the downtown area, which reduces the possibility of chance distortions, makes it possible for us to compare pollution levels from hour to hour, from season to season, and from place to place. However, it must be remembered that measuring air pollution levels only in the relatively stable downtown area of a city does not give us enough information to detect trends in overall pollution levels for a metropolitan area.

HOW POLLUTION VARIES FROM PLACE TO PLACE

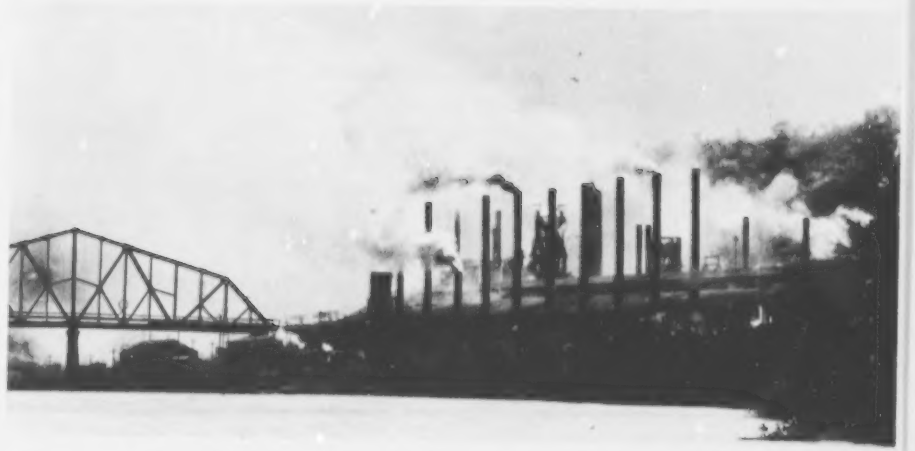
The best information we have on variation of air pollution from place to place within a city is based upon the easier-to-measure particulate matter. This type of pollution is generally highest in the industrial and old residential areas of a city,



where factory effluents combine with the wastes from coal-fired home furnaces, and is generally lowest in the newer suburbs, whose gas-heated homes are far from the factories' smokestacks. The map shows an example of a situation typical of most sizable cities.

The extent of air pollution varies as widely from one city to another as within each city. A city's size, population, climate, topography, type of industry, and amount of traffic, all exert important influences on the amount and type of waste material in the air. A large city, with much heavy industry, thousands of automobiles, and cold winters requiring extensive heating of homes, businesses, and factories, could be expected to have more pollution than a small city on the prairie, with higher winds and few industries. On the other hand, a small town in a mountain valley, where soft coal provides heat, and a cement plant or steel mill provides employment, may lie under a perpetual blanket of filth. The table at the back of this book gives relative air pollution ratings for 302 cities in the United States where particulate data have been gathered, and, to a lesser extent where gaseous pollutant data have been taken.

Although the information we have on gaseous pollutants is too limited to provide a reliable pic-



ture across the country, it can be fairly accurately stated, that where one finds tens of thousands of automobiles crawling along crowded highways toward a traffic-clogged downtown area, there one will find severe concentrations of carbon monoxide, hydrocarbons, and oxides of nitrogen, the latter two being the ingredients which go into the formation of photochemical smog. Where sulfur-bearing coal and fuel oil are used extensively for heating, electric power generation, or industrial production, there one will find an atmosphere con-

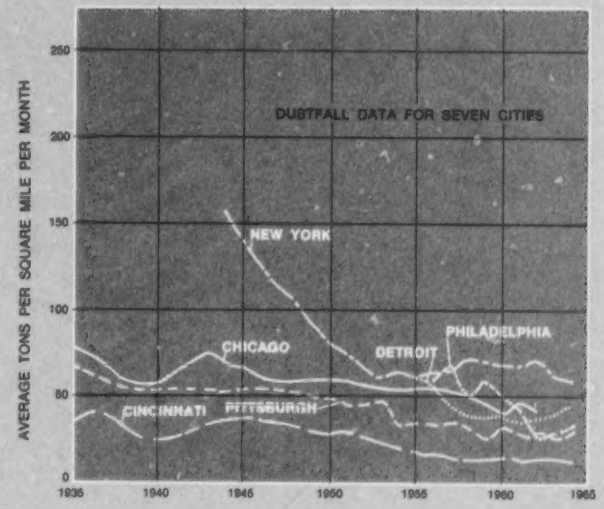
taining significant amounts of sulfur-oxides pollution.

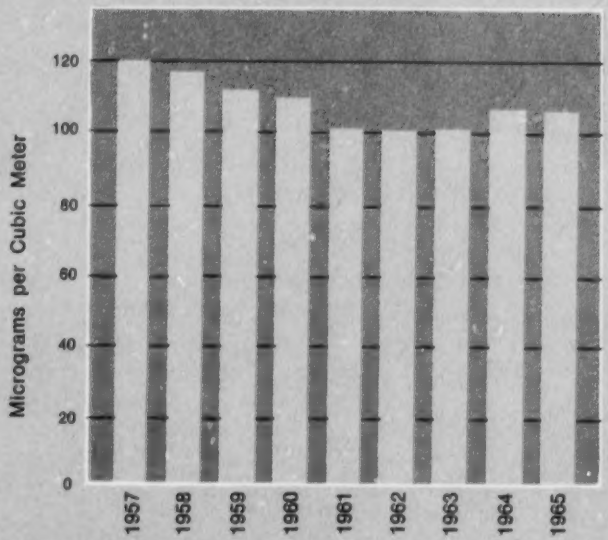
As indicated earlier, the data gathered by a single NASN or CAMP station in the downtown area of a city primarily reflect the activities of the sources in that area, and any trends in the data gathered by these downtown stations are probably due for the most part to changes in these sources. Again, it should be pointed out that these trends may not reflect changes in pollution levels for the overall metropolitan area; in most metropolitan areas the numbers and kinds of air pollution sources, especially in the area outskirts, are changing rapidly.

Data on particulate levels in the downtown areas of many cities have been gathered for a long time, and reliable analysis for trends can be made. The longest record of data available is for dustfall. In several cities smoke and fly ash were a serious problem as early as the beginning of this century, and dustfall data have been gathered for several decades. As shown in the curves for New York, Pittsburgh, Cincinnati, Detroit, Chicago, and Philadelphia, dustfall levels generally have declined over the years, with some indication of leveling off since 1955. This decline can be attributed to such fortuitous changes as the substitution of natural gas for coal in space heating, and the replacement of steam locomotives by diesel engines, as well as abatement activities directed at the obvious, visible sources of air pollution.

The data gathered by NASN on levels of suspended particulates in the downtown areas of cities also indicate a trend. As shown in the bar chart, during the period 1957 to 1961 the yearly average levels of suspended particulates in the downtown areas of our larger cities declined from 119 micrograms per cubic meter to 101 micrograms per cubic meter. Levels stayed about the same from 1961 through 1963, and then went up again in 1964 and 1965.

For the much more important gaseous pollutants, we do not have enough data to analyze for trends over the years, even for downtown areas of cities. Levels of gaseous pollution vary drastically in any one place, depending on such things as the hour of the day, the season of the year, the severity of the winter, the frequency of temperature inversions, and so on. We have continuous data on gases for the downtown areas of only a few cities, and for a period of only 5 years. Data on many more cities and for a longer period of time are needed if we are to eliminate chance variations, and come up with trends we can rely on.





TREND IN SUSPENDED PARTICULATES FOR DOWNTOWN AREAS

HOW AIR POLLUTION CHANGES FROM SEASON TO SEASON

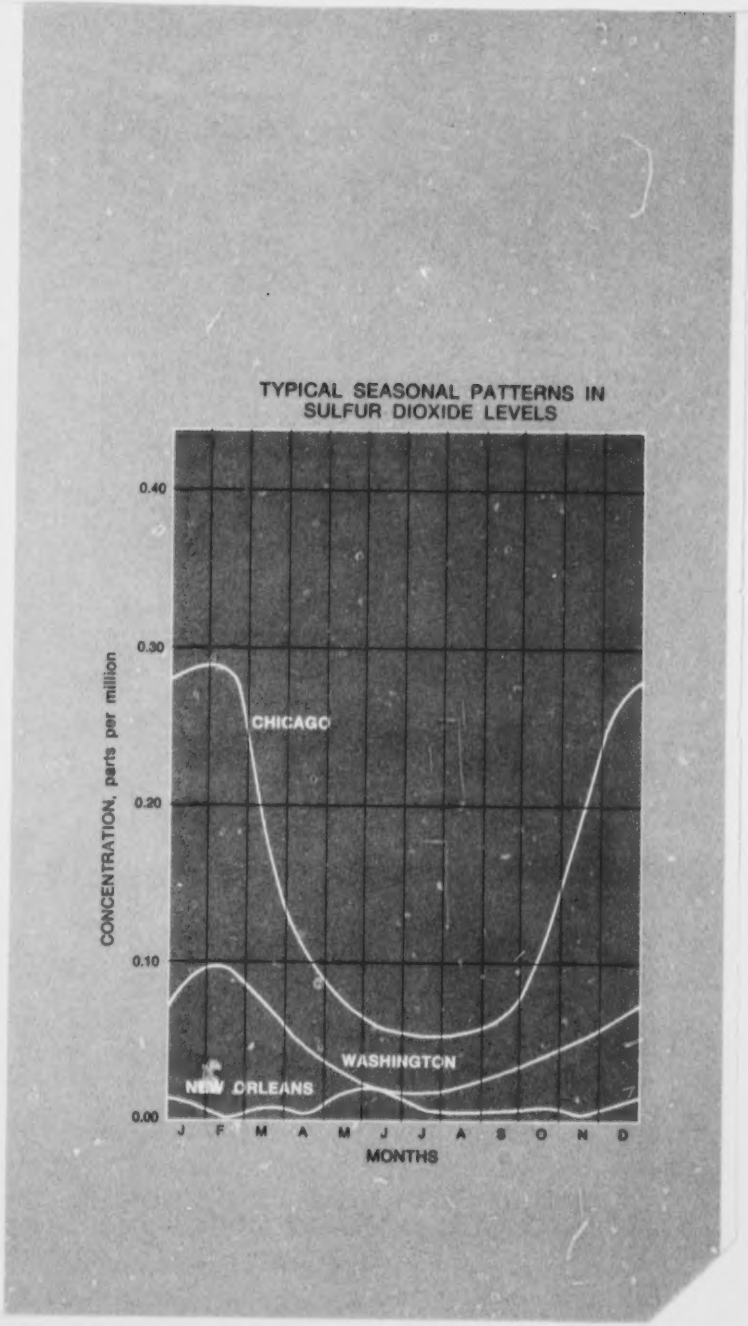
Several of the six gaseous pollutants measured at the CAMP stations show distinct patterns of variation throughout the year. The most obvious of these is sulfur dioxide, which in northeastern cities is regularly much higher in the winter, when the combustion of sulfur-bearing fuels for space heating rises sharply. The curves show typical variations in sulfur dioxide levels in three cities. Although average levels in Chicago and Washington are quite different (0.142 and 0.050 parts of sulfur dioxide per million parts of air, respectively), the seasonal pattern is quite similar, with winter levels 5 to 10 times higher than summer levels. In New Orleans, by contrast, the levels are much lower and show no consistent pattern of change. This is because natural gas, which contains little sulfur, is generally used in New Orleans for what little heating is required, as well as for most other energy needs.

The oxides of nitrogen, nitric oxide, and nitrogen dioxide, are produced during virtually any combustion process, including the burning of gasoline in the auto and the burning of gas, oil, and

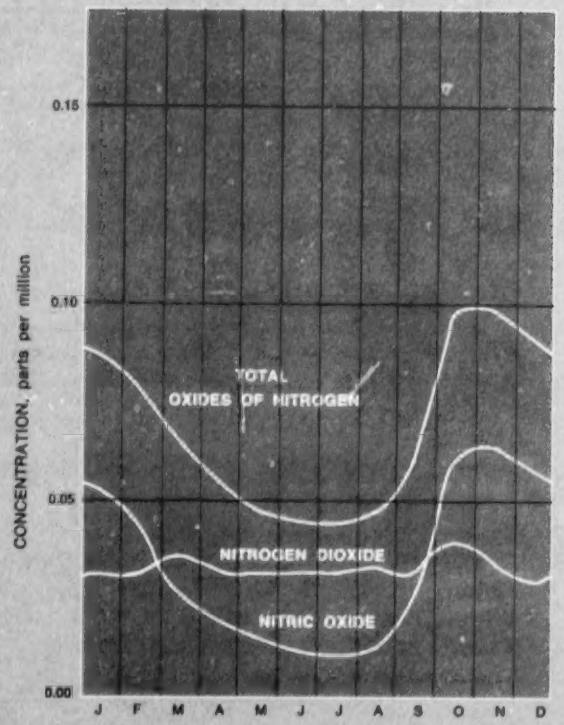
coal for space heating and electric power. It is, therefore, not surprising to find that nitrogen oxides levels are higher in winter than in summer, similar to those of sulfur dioxide. However, the time of year also affects the proportion of nitric oxide and nitrogen dioxide. In the summer, the increased temperature and sunlight convert a great deal of the nitric oxide into nitrogen dioxide.

The variations in sunlight and temperature between summer and winter are also responsible for the strong seasonal differences in levels of total oxidant measured at the CAMP stations. Total oxidant is an index of the amount of photochemical smog, which is manufactured by sunlight from oxides of nitrogen and hydrocarbons. Although in northern cities there are more of these raw materials in the air in the winter, the winter sun may not be strong enough to trigger the chemical reactions in the air. This seasonal difference becomes less pronounced as we move south.

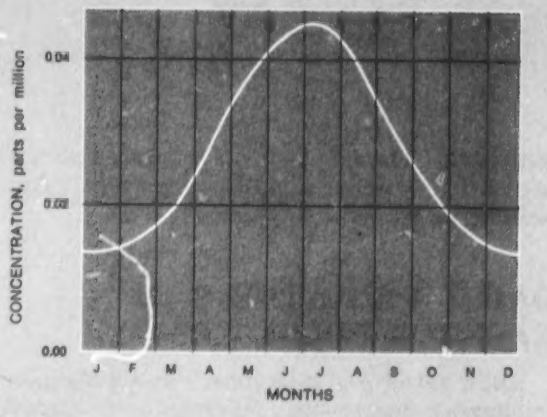
Suspended particulates in the air generally exhibit somewhat less seasonal variation than do the gases. The pattern for the very smallest suspended particulate matter is similar to that for sulfur dioxide; since such fine particulates are often associated with fuel combustion, this is not



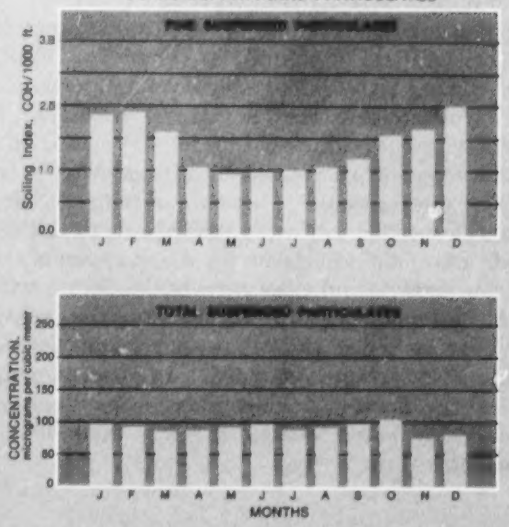
NITROGEN DIOXIDE AND NITRIC OXIDE



SEASONAL PATTERNS
OF TOTAL OXIDANT LEVELS



SEASONAL PATTERNS PARTICULATES

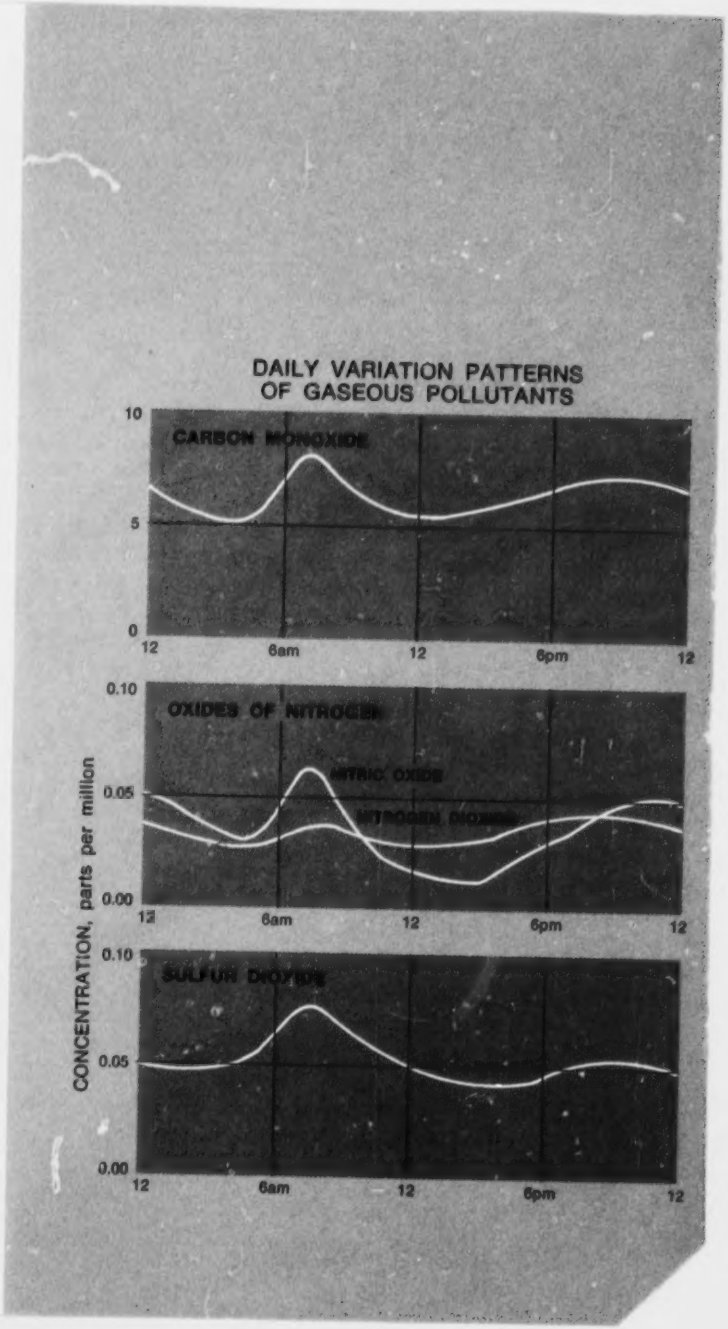


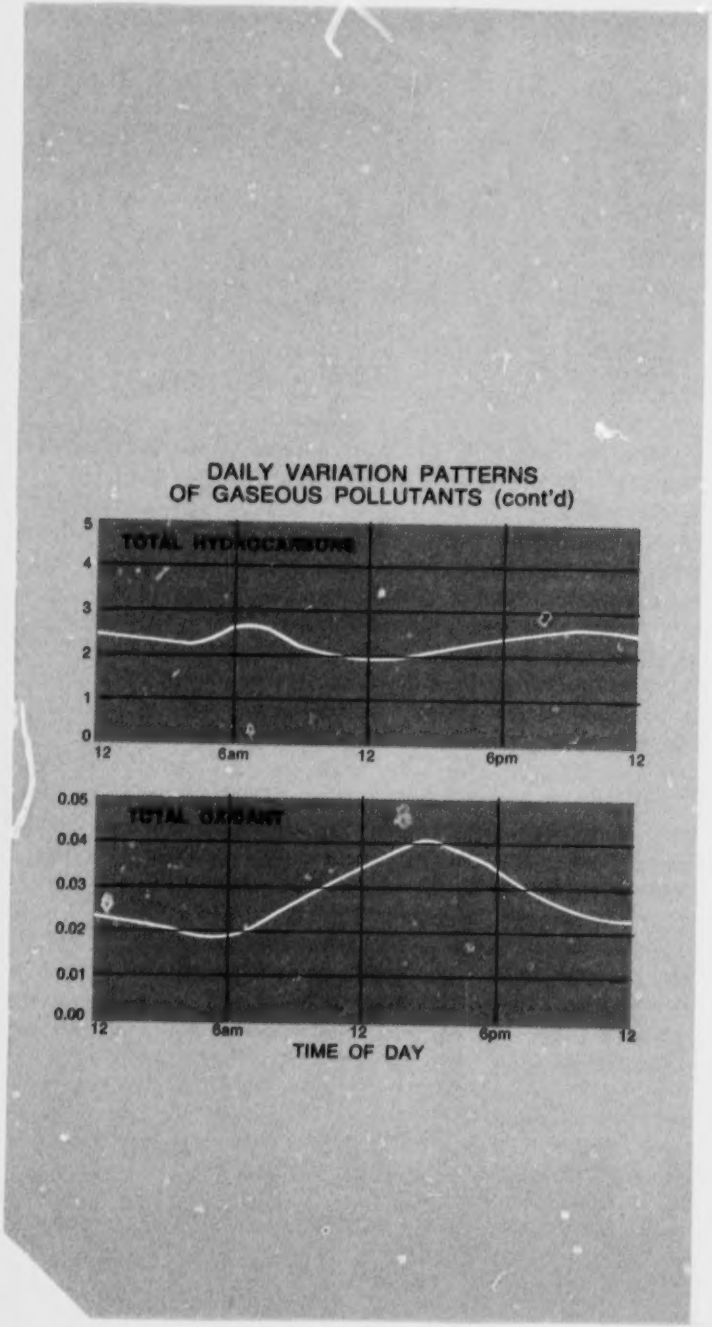
surprising. The data on gross suspended particulate matter, however, as gathered by a high-volume sampler, do not show any pattern at all.

DAILY VARIATIONS IN GASEOUS POLLUTION

Daily patterns of atmospheric levels of gaseous pollutants reflect pronounced cycles in the capacity of the air to disperse pollution and in the rate at which human activity produces it.

Pollutants emitted into the atmosphere may be dispersed either horizontally or vertically. Windspeed during the day is generally higher than at night which means that horizontal dispersion is generally greater during the day. Vertical dispersion of pollution depends on a somewhat more complex phenomenon. Normally during the day the air closest to the ground becomes warmer than the air above it. As this air warms, it expands and becomes lighter, and rises carrying pollution with it. At night, however, the air closest to the ground may even be cooler than that above, and vertical mixing of pollution is stopped. In general, then, vertical and horizontal dispersion mechanisms are considerably better during the day than during the night.





Most of man's activities either begin or increase rapidly in the morning—rush hour traffic, start-up of boilers and heating plants, increased electric power generation, and so on. All these activities contribute pollution to the atmosphere before the stable atmospheric conditions that typically occur at night have broken up, and pollutants accumulate until they reach much higher than normal levels. This is particularly true of the pollutants resulting from rush hour motor vehicle traffic. Following a morning peak each of these pollutants, except total oxidant, typically reaches a low point in midafternoon. This is because the rate of pollutant emissions has by this time lessened somewhat, while the ability of the atmosphere to disperse pollution is at its maximum for the day. At the time of the evening rush hour traffic, this improved atmospheric dispersion capacity is still generally present, so that most communities are spared a repetition of the high levels experienced during the morning. By later in the evening, however, poor atmospheric dispersion characteristics establish themselves again, and concentrations of pollution rise to a broader peak for the night.

Concentrations of total oxidant do not follow the daily cycle described above as typical for the other pollutants. The level of oxidizing chemicals

in the air is strongly dependent on sunlight, which provides the energy for the formation of oxidants from the hydrocarbons and nitrogen oxides. Levels of oxidant begin to rise between 6 and 7 a.m., at about the time of the morning peak of hydrocarbon and oxides of nitrogen. Depending on the sunshine and temperature, concentrations then continue to rise, reaching a maximum in midafternoon, and declining as evening comes on.

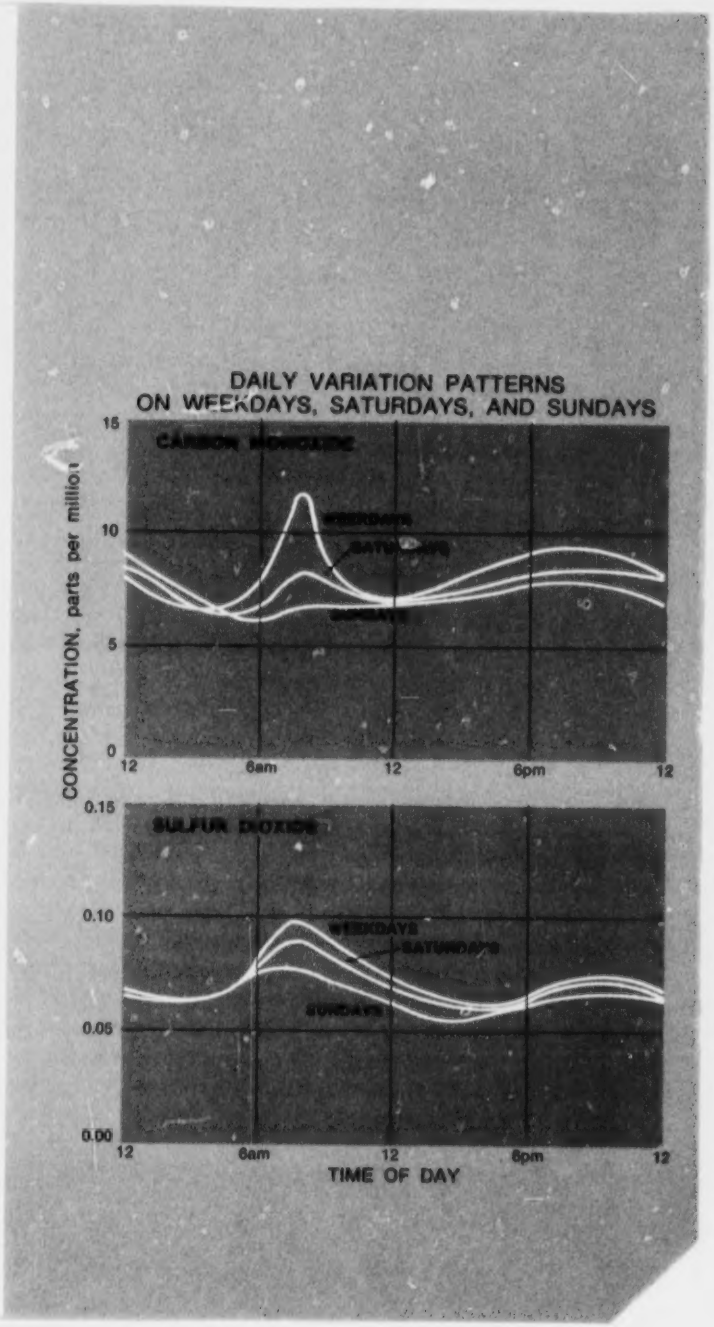
WEEKLY CYCLES

The one situation in which the daily cycles are dramatically altered occurs once every week when the working population of our cities goes home Friday night and does not come back for 2 days. On Sundays there is essentially no morning peak in carbon monoxide levels, while the morning peak in sulfur dioxide concentrations is still there, although significantly lower than on weekdays. In each case, the pattern on Saturdays is intermediate between the Sunday and weekday patterns.

It is also interesting to note that carbon monoxide levels are highest late Saturday night, apparently reflecting the popularity of downtown attractions on Saturday night.

SUMMARY

The air quality sampling activities carried on



by the many air pollution agencies in the Nation give us the answers to some of the questions we ask about the quality of the air we breathe. The most significant conclusion to be drawn from the data is that wherever we have looked for air pollution we have found it.

The data give us a great deal of information about the way in which levels of pollution vary with changes in location, and in time of year and day. Pollution levels are generally higher in large cities than in smaller towns, in industrial neighborhoods than in suburbs. The levels of many pollutants are greater in winter than in summer, in the morning than in the afternoon, on weekdays than on Sundays.

The data we presently have, however, only partly define the long-term trends in pollutant levels, and it is apparent that much more sampling must be done, perhaps in new ways, if we are to obtain direct evidence of trends that we can now only intuitively know.

HOW IS THE AIR IN YOUR CITY?

The table that follows lists 302 cities in the United States and assigns to each a relative rating from 1 through 5 for each of several pollutants. San Francisco, for example, has the best rating, 1, for total suspended particulates, but has the next to worst rating, rating 4, for nitrogen dioxide.

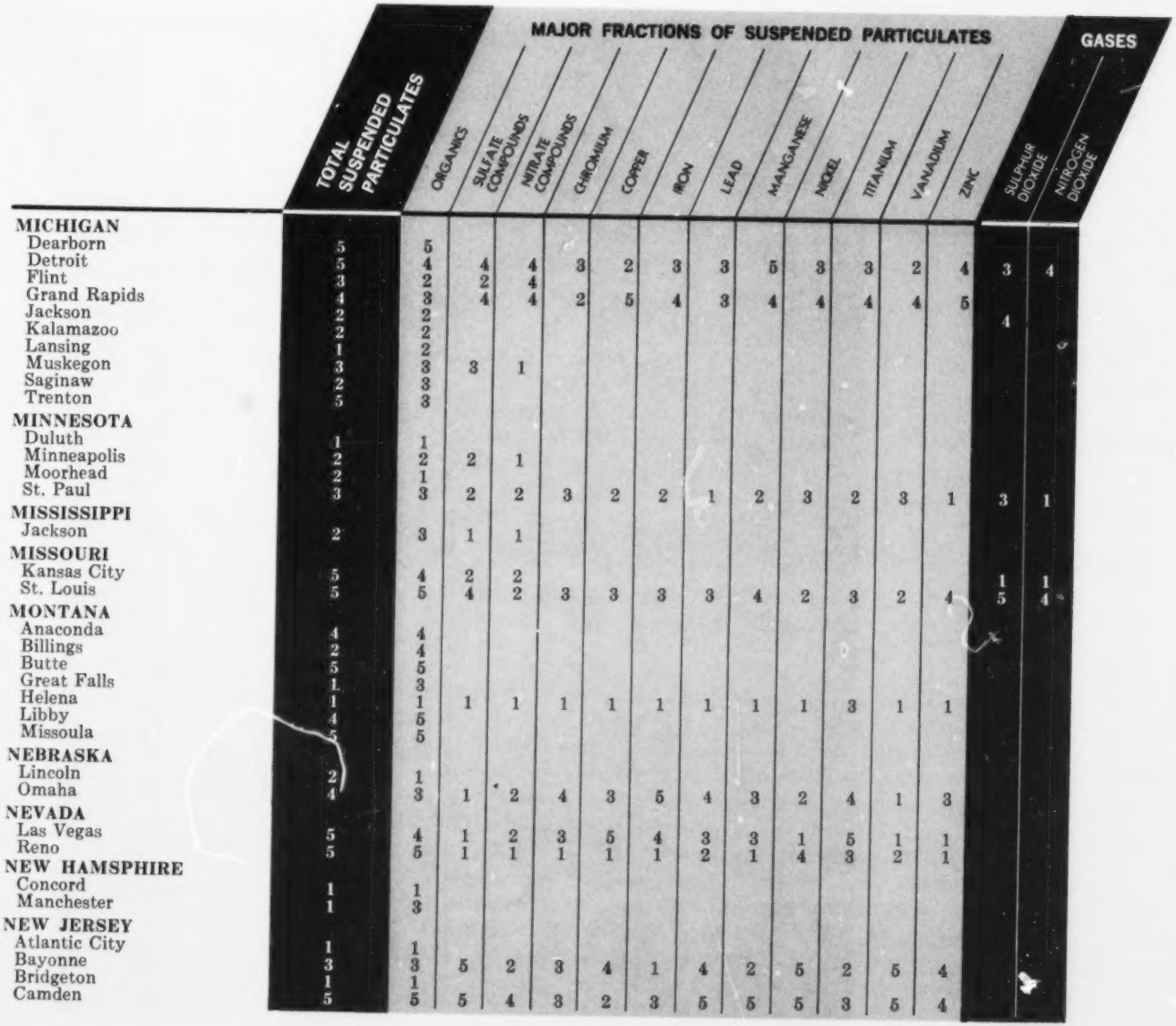
In general, a city's rating for total suspended particulate matter will be pretty much the same as the ratings for each of the major fractions of suspended matter. However, taken altogether, these ratings sometimes can give us a sort of pollution source fingerprint for a city. For example, if the fraction ratings are lower than the rating for total suspended particulates, the city probably has a lot of natural—as opposed to man made—pollution. On the other hand, a high organic fraction rating indicates that human activities are contributing significantly to pollution. Organic material in the air derives from such things as the incomplete combustion of fuels and refuse. A high rating for the sulfate fraction points to the use of sulfur-bearing fuels, such as coal and oil. A high lead rating may mean dense automobile traffic—burning leaded gasoline—or may point to a smelting operation. High iron points to an iron or steel industry, and high copper to a smelter. The other metals indicate specific foundry operations, plating and alloying processes, and the manufacture of pigments.

Turning to the gases, high sulfur dioxide, like high sulfate, points to the use of sulfur-bearing fuels, and high nitrogen dioxide may very well mean frequent photochemical smogs.

	TOTAL SUSPENDED PARTICULATES	MAJOR FRACTIONS OF SUSPENDED PARTICULATES												GASES	
		ORGANICS	SULFATE COMPOUNDS	NITRATE COMPOUNDS	CHROMIUM	COPPER	IRON	LEAD	MANGANESE	NICKEL	TITANIUM	VANADIUM	ZINC	SULPHUR DIOXIDE	NITROGEN DIOXIDE
ALASKA															
Anchorage	2	1	1	1											
ALABAMA															
Birmingham	5	5	3	3	3	4	4	3	5	2	5	2	5	2	4
Mobile	4	5	2	3											
ARIZONA															
Phoenix	5	5	2	4	2	3	5	5	4	3	5	1	4	1	3
Tucson	4	2	1	1											
ARKANSAS															
Little Rock	2	2	1	2											
Texarkana	1	2													
CALIFORNIA															
Bakersfield	5	5	3	5											
Berkeley	2	3													
Burbank	5	5	3	5											
Fresno	3	3													
Glendale	4	5													
Long Beach	5	5													
Los Angeles	5	5	4	5	4	4	5	5	3	4	5	4	4	1	5
Monterey	1	1													
Oakland	2	4	2	5											
Pasadena	5	5	4	5	4	5	5	5	4	5	5	4	5	2	5
Richmond	1	1													
Sacramento	1	3	1	5											
San Bernardino	5	5													
San Diego	2	4	2	5											
San Francisco	1	3	2	3	3	2	1	4	1	3	2	3	3	1	4
San Jose	3	5													
Santa Ana	4	2	2	5											
Santa Barbara	2	3	1	5	2	1	1	2	1	2	1	2	1		
Stockton	1	3													
COLORADO															
Denver	5	5	1	4	2	4	4	4	4	4	5	2	3	2	2
Pueblo	4	2			1	2	3	5	3	1	2	1	5		
CONNECTICUT															
Bridgeport	3	3													
Hartford	3	3	5	3										4	4
New Britain	3	4													
New Haven	3	3	5	3										5	3
Norwich	1	2			1	1	1	2	1	3	2	4	2		
Waterbury	2	2													
DELAWARE															
Newark	2	1													
Wilmington	5	5	5	4										5	4

	TOTAL SUSPENDED PARTICULATES	MAJOR FRACTIONS OF SUSPENDED PARTICULATES												GASES	
		ORGANICS	SULFATE COMPOUNDS	NITRATE COMPOUNDS	CHROMIUM	COPPER	IRON	LEAD	MANGANESE	NICKEL	TITANIUM	VANADIUM	ZINC	SULPHUR DIOXIDE	NITROGEN DIOXIDE
DISTRICT OF COLUMBIA															
Washington	3	4	4	2	3	4	2	4	2	4	3	5	2	1	4
FLORIDA															
Jacksonville	1	2													
Miami	1	2													
Orlando	2	2													
St. Petersburg	1	1			2	1	1	1	1	1	1	3	1		
Tampa	2	3													
GEORGIA															
Atlanta	3	3	1	3	2	1	2	4	4	1	3	2	5	2	4
Augusta	1	3													
Columbus	2	4													
Macon	4	3													
Savannah	2	3													
HAWAII															
Honolulu	1	1	1	1											
IDAHO															
Boise City	2	4	1	1	2	1	2	2	2	1	3	1	1	2	1
ILLINOIS															
Chicago	5	5	5	2	4	5	4	5	4	5	3	4	5	5	5
East St. Louis	5	5			4	4	5	5	4	3	4	2	5		
Joliet	4	3			1	1	3	2	3	2	1	3	4		
Moline	3	1	2	4											
North Chicago	3	2			1	3	3	2	3	1	2	2	5		
Peoria	5	4	3	4											
Rockford	2	2													
Rock Island	5	3	2	5											
Springfield	4	2			3	1	3	1	2	2	1	3	3		
INDIANA															
Beverly Shores	1	1												2	
Dunes Police Post	1	1													
Dunes State Park	1														
East Chicago	5	4	5	4	5	5	5	4	5	5	4	4	5	5	3
Evansville	3	5	3	2											
Fort Wayne	4	3	3	5											
Gary	5	5												4	3
Hammond	5	4													
Indianapolis	5	5	4	4	4	3	4	4	4	4	4	3	3	4	4
Muncie	3	3	2	5	2	5	1	3	3	1	1	1	2		
Portage	4	1												2	
South Bend	4	3	4	3											
Terre Haute	4	5	3	3											
West Lafayette	1														

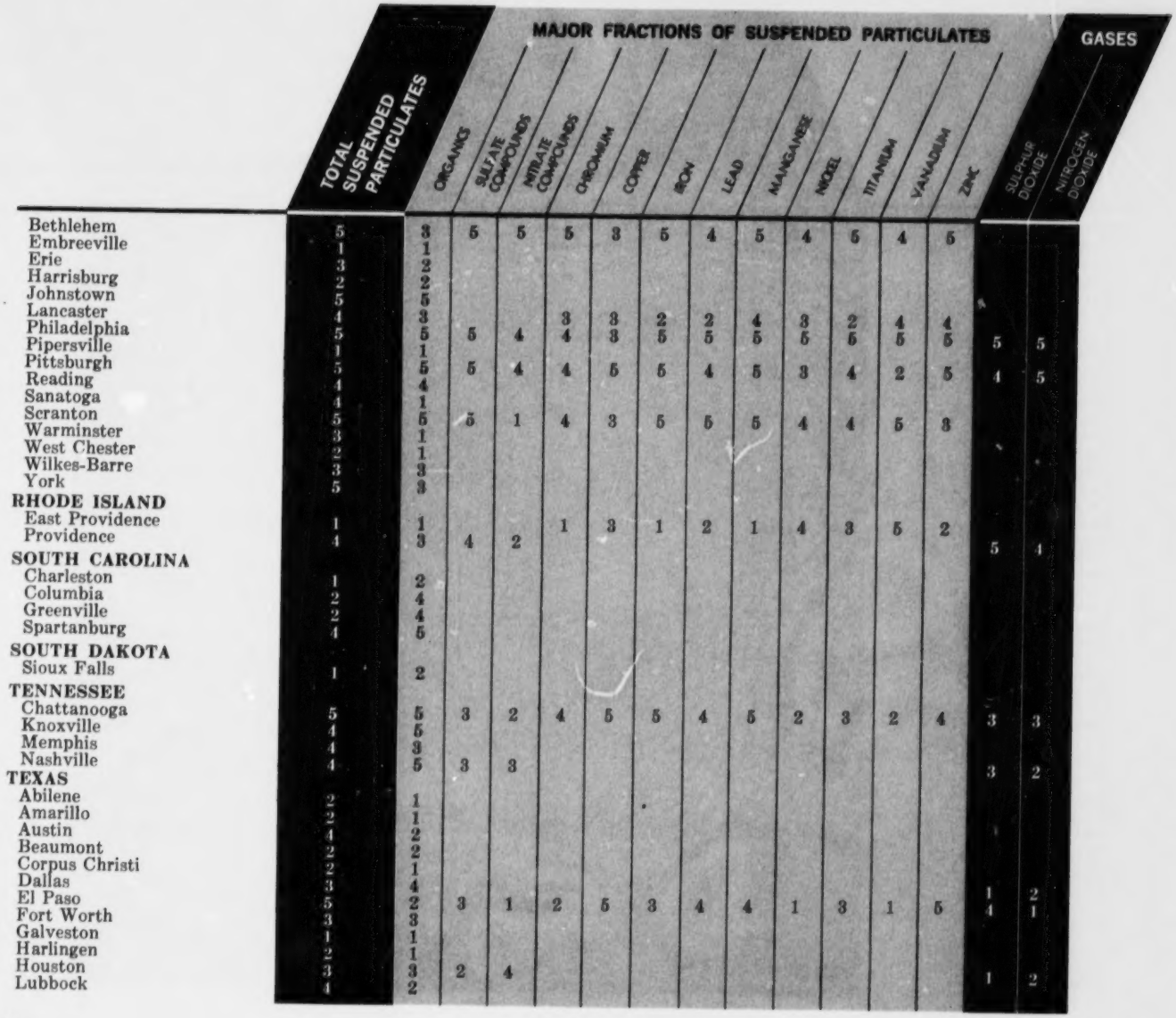
	TOTAL SUSPENDED PARTICULATES	MAJOR FRACTIONS OF SUSPENDED PARTICULATES												GASES	
		ORGANICS	SULFATE COMPOUNDS	NITRATE COMPOUNDS	CHROMIUM	COPPER	IRON	LEAD	MANGANESE	NICKEL	TITANIUM	VANADIUM	ZINC	SULPHUR DIOXIDE	NITROGEN DIOXIDE
IOWA															
Cedar Rapids	5	2			1	1	2	1	3	2	2	1	1		
Davenport	4	4													
Des Moines	4	4	2	2	2	2	2	1	2	1	2	1	2	2	1
Dubuque	5	2	2	3											
KANSAS															
Kansas City	5	4	1	2											
Topeka	2	2													
Wichita	3	2	1	2										1	1
KENTUCKY															
Ashland	5	5	5	4											
Covington	4	4	3	5										4	
Lexington	1	1													
Louisville	5	4	4	5											
LOUISIANA															
Baton Rouge	4	4	1	1											
Lake Charles	2	1			1	1	1	1	1	1	1	1	1		
New Orleans	3	4	3	4	3	2	1	2	1	3	1	4	1	2	3
Shreveport	4	4													
MAINE															
Portland	2	2													
MARYLAND															
Annapolis	1	3													
Baltimore	5	5	5	2	5	5	4	5	4	5	4	5	4	5	5
Cumberland	5	5	4	2	1	1	2	1	2	2	2	2	2		
Fort Howard	1	2													
Hagerstown	3	5													
Riviera Beach	2	3													
Rockville	1	2													
Salisbury	1	3													
Westminster	1	2													
MASSACHUSETTS															
Boston	4	5	5	1	2	2	2	4	2	5	2	5	3	5	5
Brockton	1	4													
Cambridge	3	4													
Fall River	4	4													
Lawrence	1	3													
Lowell	1	3													
Lynn	2	5													
New Bedford	1	2													
Quincy	3	5													
Somerville	1	3													
Springfield	1	3	4	3											
Worcester	3	4													



MICHIGAN															
Dearborn	5	5													
Detroit	5	4	4	4	3	2	3	3	5	3	3	2	4	3	4
Flint	3	2	2	4											
Grand Rapids	4	3	4	4	2	5	4	3	4	4	4	4	5		
Jackson	2	2												4	
Kalamazoo	2	2													
Lansing	1	2													
Muskegon	3	3	3	1											
Saginaw	2	3													
Trenton	5	3													
MINNESOTA															
Duluth	1	1													
Minneapolis	2	2	2	1											
Moorhead	2	1													
St. Paul	3	3	2	2	3	2	2	1	2	3	2	3	1	3	1
MISSISSIPPI															
Jackson	2	3	1	1											
MISSOURI															
Kansas City	5	4	2	2										1	1
St. Louis	5	5	4	2	3	3	3	3	4	2	3	2	4	5	4
MONTANA															
Anaconda	4	4													
Billings	2	4													
Butte	5	5													
Great Falls	1	3													
Helena	1	1	1	1	1	1	1	1	1	1	3	1	1		
Libby	4	5													
Missoula	5	5													
NEBRASKA															
Lincoln	2	1													
Omaha	4	3	1	2	4	3	5	4	3	2	4	1	3		
NEVADA															
Las Vegas	5	4	1	2	3	5	4	3	3	1	5	1	1		
Reno	5	5	1	1	1	1	1	2	1	4	3	2	1		
NEW HAMSPHIRE															
Concord	1	1													
Manchester	1	3													
NEW JERSEY															
Atlantic City	1	1													
Bayonne	3	3	5	2	3	4	1	4	2	5	2	5	4		
Bridgeton	1	1													
Camden	5	5	5	4	3	2	3	5	5	5	3	5	4		

	TOTAL SUSPENDED PARTICULATES	MAJOR FRACTIONS OF SUSPENDED PARTICULATES												GASES	
		ORGANICS	SULFATE COMPOUNDS	NITRATE COMPOUNDS	CHROMIUM	COPPER	IRON	LEAD	MANGANESE	NICKEL	TITANIUM	VANADIUM	ZINC	SULPHUR DIOXIDE	NITROGEN DIOXIDE
East Orange	1	2													
Elizabeth	4	4													
Glassboro	1	1													
Hamilton	3	2													
Jersey City	5	5	5	2											
Jutland	1	1													
Marlton	3														
Newark	4	4	5	3	4	4	4	4	2	5	3	5	4		
Paterson	3	3			2	4	1	5	2	5	2	5	3	5	5
Pemberton	1	1													
Perth Amboy	5	2													
Princeton	3	2													
Trenton	3	2													
NEW MEXICO															
Albuquerque	5	5	1	1										1	1
NEW YORK															
Albany	2	1	4	5											
Binghamton	3	3	3	3											
Buffalo	4	2			2	4	4	1	5	3	3	4	3	3	3
Elmira	1	2													
Glen Cove	4	4			4	5	3	3	2	4	2	5	3		
Massena	1	1			4	1	1	1	1	3	1	4	2		
Mount Vernon	4	4	4	3	5	2	3	5	2	5	2	5	4		
New Rochelle	4	5			4	4	4	5	2	5	3	5	4		
New York	5	5	5	3	4	4	4	5	3	5	4	5	4	5	5
Niagara Falls	5	2													
Rochester	3	2			5	2	3	2	3	5	3	4	3		
Schenectady	3	4	4	4											
Syracuse	4	4	3	5											
Troy	2	1			3	3	2	2	2	4	2	5	2		
Utica	3	3	3	4											
Yonkers	5														
NORTH CAROLINA															
Asheville	3	5													
Charlotte	4	5	2	2	2	3	2	3	2	1	3	3	2		
Durham	4	5		2	2	1	2	2	2	2	3	3	1		
Fayetteville	1	1													
Gastonia	1														
Goldsboro	1														
Greensboro	1	2													
Raleigh	1	2													
Salisbury	3														
Wilmington	1														
Winston-Salem	4	5	3	1	3	3	3	2	3	2	5	3	3		

	TOTAL SUSPENDED PARTICULATES	MAJOR FRACTIONS OF SUSPENDED PARTICULATES												GASES	
		ORGANICS	SULFATE COMPOUNDS	NITRATE COMPOUNDS	CHROMIUM	COPPER	IRON	LEAD	MANGANESE	NICKEL	TITANIUM	VANADIUM	ZINC	SULPHUR DIOXIDE	NITROGEN DIOXIDE
NORTH DAKOTA															
Bismark	3	1													
Fargo	3	1													
OHIO															
Akron	4	4	4	5											
Ashland	3	3													
Ashtabula	3	2													
Athens	3	4													
Cadiz	2	3													
Canton	5	5			5	5	5	3	5	5	5	2	5		
Celina	2	2													
Cincinnati	4	4	4	3	5	3	5	4	5	2	3	2	5	3	3
Cleveland	4	4	5	3	4	5	4	3	5	3	3	2	4	5	5
Coshocton	5	5													
Columbus	4	3	4	4	5	5	5	3	5	4	5	2	4	2	3
Dayton	4	3	4	4										3	2
Delaware	3	3													
Dover	3	4													
Hamilton	3	3													
Hillsboro	3	3													
Jackson	4	5													
London	2	3													
Lorain	4	1	3	5											
Mansfield	4	4													
Painesville	3	3													
Piqua	5	5													
Springfield	2	2													
Steubenville	5	5	5	5											
Tiffin	3	2													
Toledo	3	2													
Youngstown	5	5	4	3										4	2
Wauson	2	1													
Waverly	4														
Zanesville	4														
OKLAHOMA															
Oklahoma City	2	2	1	1	5	3	3	3	2	2	3	1	3		
Tulsa	1	1	1	1	3	3	1	1	2	1	1	1	3	1	3
OREGON															
Eugene	3	5			5	5	3	1	3	3	5	3	2		
Medford	4	5			5	2	4	1	5	4	5	4	2		
Portland	4	4	3	5										3	2
PENNSYLVANIA															
Allentown	3	2	5	5	5	4	5	5	5	3	5	5	5		
Altoona	4	5	4	3	2	5	3	1	4	2	2	3	3		



	TOTAL SUSPENDED PARTICULATES	ORGANICS	SULFATE COMPOUNDS	NITRATE COMPOUNDS	CHROMIUM	COPPER	IRON	LEAD	MANGANESE	NICKEL	TITANIUM	VANADIUM	ZINC	SULPHUR DIOXIDE	NITROGEN DIOXIDE
Bethlehem	5	3	5	5	5	3	5	4	5	4	5	4	5		
Embreeville	1	1													
Erie	3	2													
Harrisburg	2	2													
Johnstown	5	5													
Lancaster	4	3			3	3	2	2	4	3	2	4	4		
Philadelphia	5	5	5	4	4	3	5	5	5	5	5	5	5	5	5
Pipersville	1	1													
Pittsburgh	5	5	5	4	4	5	5	4	5	3	4	2	5	4	5
Reading	4	4													
Sanatoga	4	1													
Scranton	5	5	5	1	4	3	5	5	5	4	4	5	3		
Warminster	3	1													
West Chester	2	1													
Wilkes-Barre	3	3													
York	5	3													
RHODE ISLAND															
East Providence	1	1			1	3	1	2	1	4	3	5	2		
Providence	4	3	4	2										5	4
SOUTH CAROLINA															
Charleston	1	2													
Columbia	2	4													
Greenville	2	4													
Spartanburg	4	5													
SOUTH DAKOTA															
Sioux Falls	1	2													
TENNESSEE															
Chattanooga	5	5	3	2	4	5	5	4	5	2	3	2	4	3	3
Knoxville	4	5													
Memphis	4	3													
Nashville	4	5	3	3										3	2
TEXAS															
Abilene	2	1													
Amarillo	2	1													
Austin	4	2													
Beaumont	2	2													
Corpus Christi	2	1													
Dallas	3	4													
El Paso	5	2	3	1	2	5	3	4	4	1	3	1	5	1	2
Fort Worth	3	3												4	1
Galveston	1	1													
Harlingen	2	1													
Houston	3	3	2	4										1	2
Lubbock	4	2													

	TOTAL SUSPENDED PARTICULATES	MAJOR FRACTIONS OF SUSPENDED PARTICULATES												GASES	
		ORGANICS	SULFATE COMPOUNDS	NITRATE COMPOUNDS	CHROMIUM	COPPER	IRON	LEAD	MANGANESE	NICKEL	TITANIUM	VANADIUM	ZINC	SULPHUR DIOXIDE	NITROGEN DIOXIDE
Odessa	5	2			1	1	3	3	2	3	3	3	1		
San Angelo	2	1													
San Antonio	2	2													
Texarkana	2	1													
Texas City	1	1													
Tyler	1	1			2	1	2	1	1	2	1	3	2		
Waco	3	1													
Wichita Falls	5	2													
UTAH															
Ogden City	4	4													
Salt Lake City	4	4	3	4										2	3
VERMONT															
Burlington	1	2													
VIRGINIA															
Danville	2	3													
Hampton	1	1													
Lynchburg	4	5													
Norfolk	4	2	5	3										3	2
Portsmouth	2	3													
Richmond	3	4													
Roanoke	2	4													
WASHINGTON															
Bellingham	1														
Clarkston	5														
Everett	2														
Seattle	2	4	2	1	4	1	2	4	2	5	2	4	2	1	2
Spokane	3	3			5	5	4	1	2	2	5	3	2		
Tacoma	2	4	2	1	2	5	1	2	2	4	2	4	1		
Vancouver	3														
WEST VIRGINIA															
Charleston	5	4	5	1	5	4	5	4	5	4	5	4	4	2	3
Huntington	4	4	3	3											
Weirton	5	4													
Wheeling	5	4													
WISCONSIN															
Eau Claire	1	1													
Kenosha	3	2													
Madison	2	2													
Milwaukee	4	3	3	3	2	3	4	2	4	3	4	2	2	3	1
Racine	3	1													
Superior	1	1													
WYOMING															
Cheyenne	1	1	1	1	1	3	1	1	1	1	2	1	1		